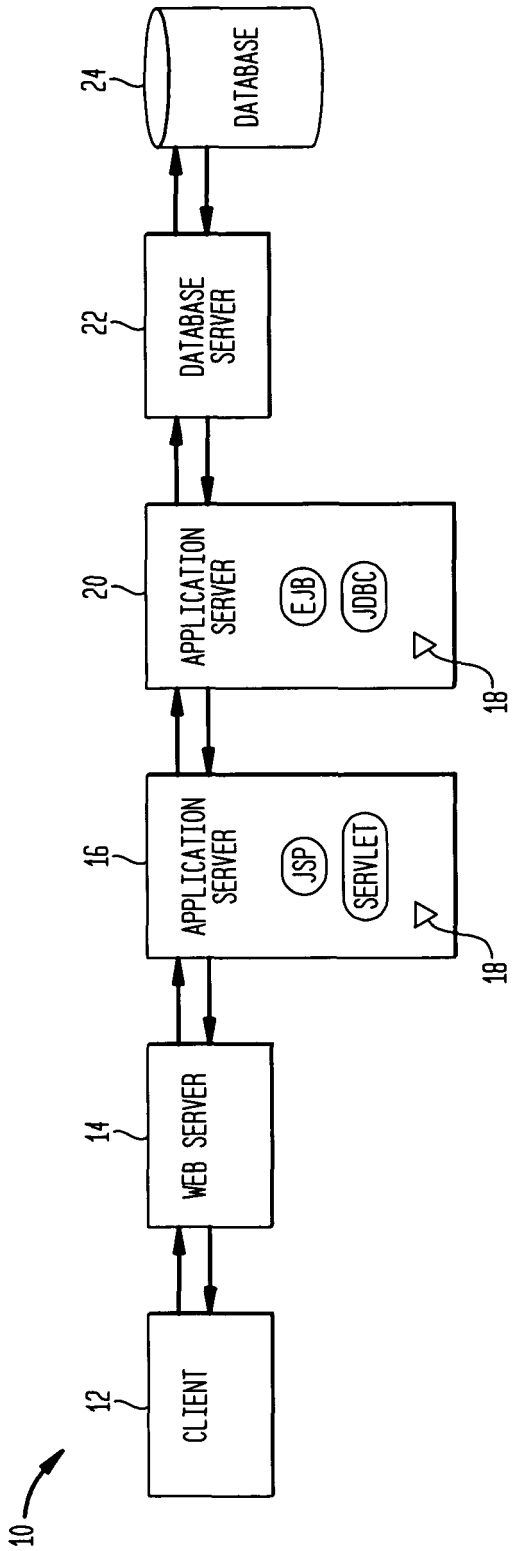
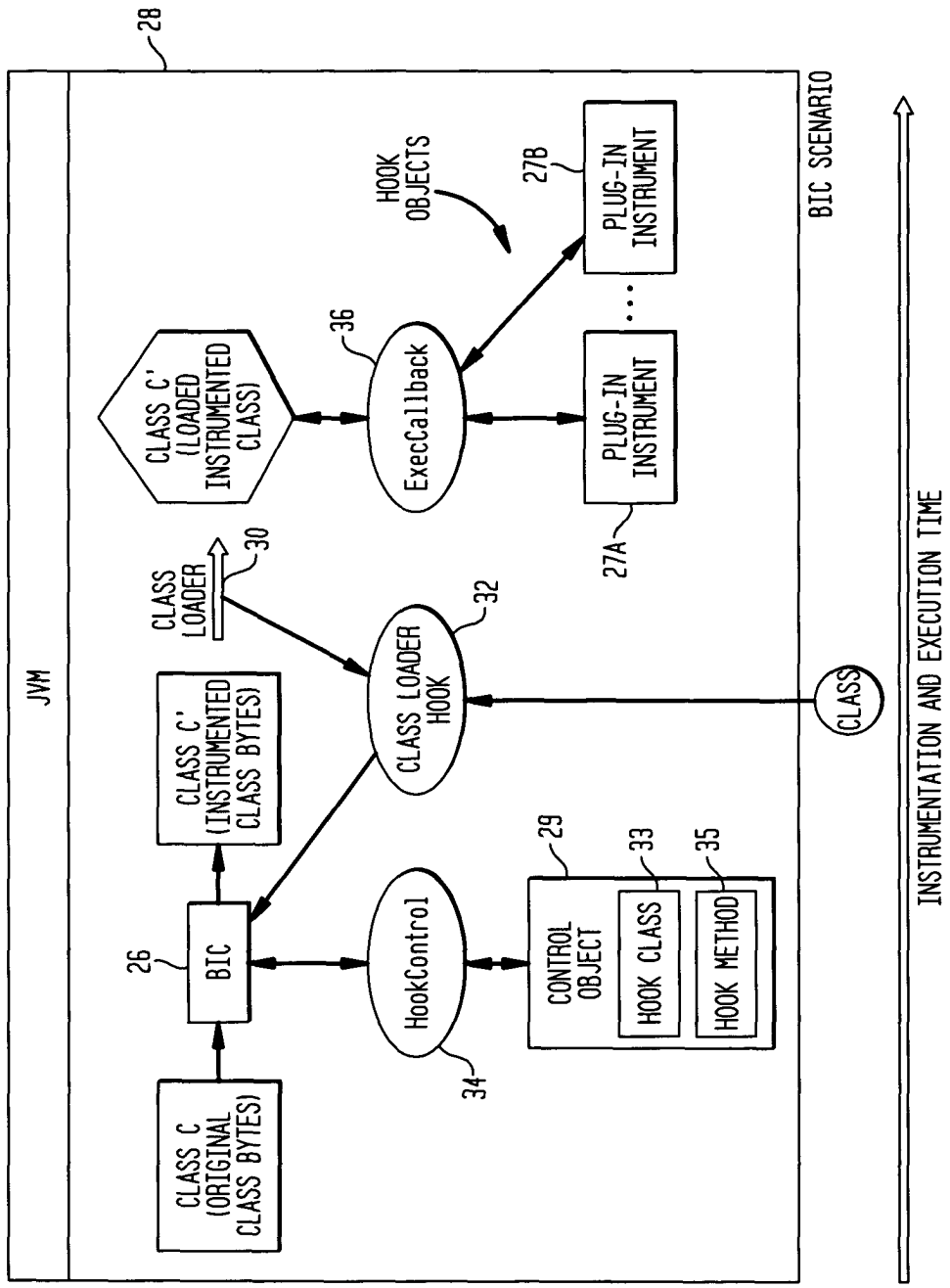

10
12
CLIENT
14
WEB SERVER
16
APPLICATION SERVER
JSP
SERVLET
18
20
APPLICATION SERVER
EJB
JDBC
18
22
DATABASE SERVER
24
DATABASE

FIG. 1

FIG. 2


28
JVM
CLASS C (ORIGINAL CLASS BYTES)
26
BIC
CLASS C' (INSTRUMENTED CLASS BYTES)
CLASS LOADER
30
CLASS C' (LOADED INSTRUMENTED CLASS)
HOOK OBJECTS
36
ExecCallback
27B
PLUG-IN INSTRUMENT
27A
PLUG-IN INSTRUMENT
CLASS LOADER HOOK
32
HookControl
34
CONTROL OBJECT
29
HOOK CLASS
33
HOOK METHOD
35
CLASS
BIC SCENARIO
INSTRUMENTATION AND EXECUTION TIME

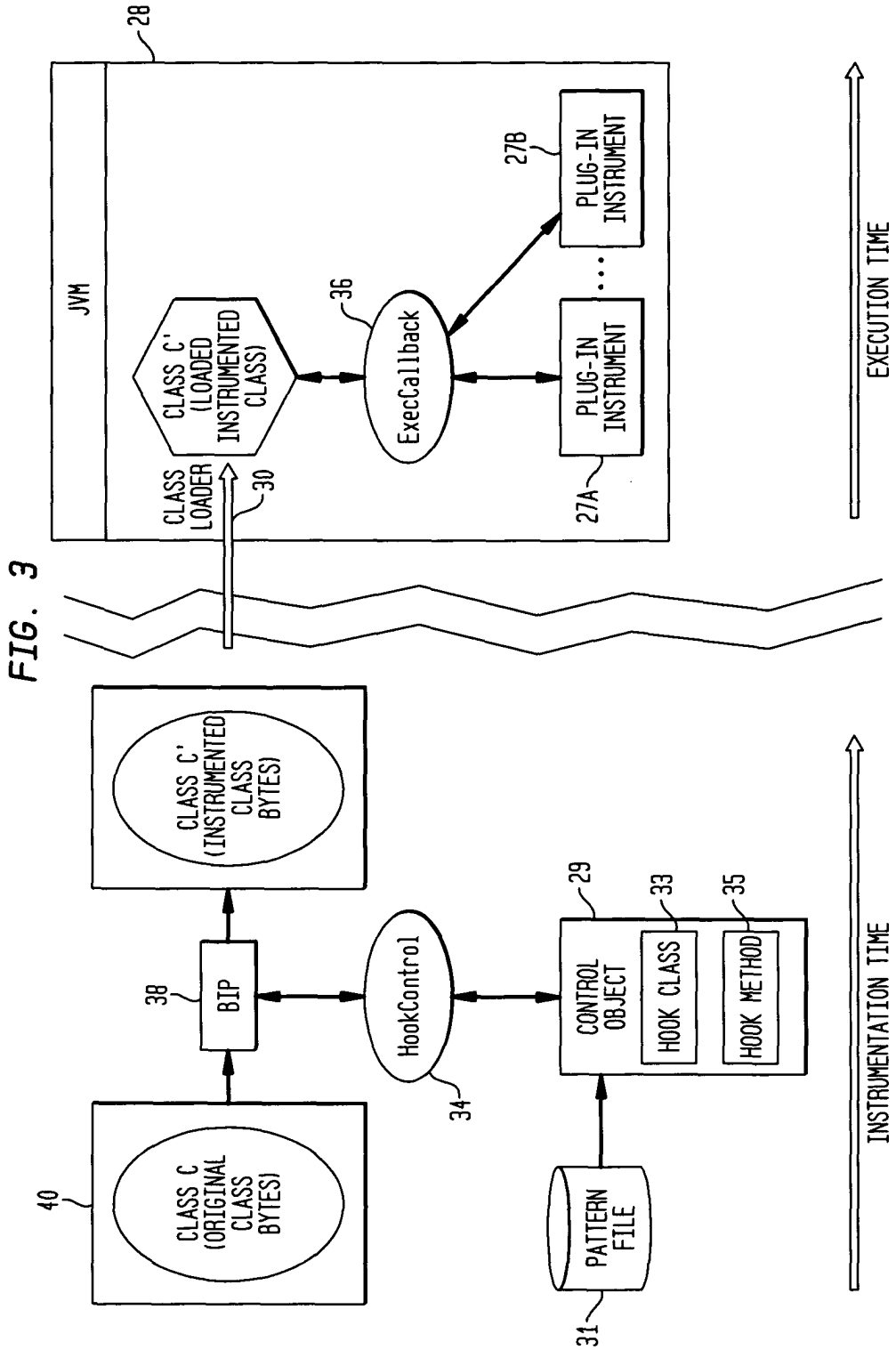

28
JVM
CLASS C' (LOADED INSTRUMENTED CLASS)
CLASS LOADER
30
36
ExecCallback
27B
PLUG-IN INSTRUMENT
PLUG-IN INSTRUMENT
27A
EXECUTION TIME
CLASS C' (INSTRUMENTED CLASS BYTES)
38
BIP
HookControl
34
29
CONTROL OBJECT
33
HOOK CLASS
35
HOOK METHOD
40
CLASS C (ORIGINAL CLASS BYTES)
PATTERN FILE
31
INSTRUMENTATION TIME

FIG. 3

FIG. 4

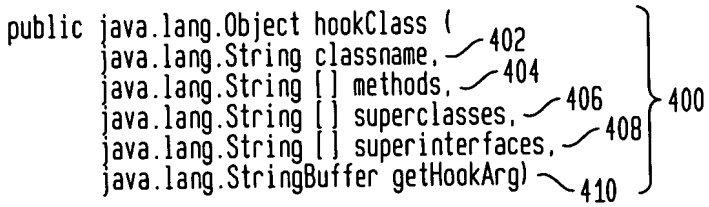

public java.lang.Object hookClass (
java.lang.String classname,
java.lang.String [] methods,
java.lang.String [] superclasses,
java.lang.String [] superinterfaces,
java.lang.StringBuffer getHookArg)
402
404
406
408
410
400

FIG. 5

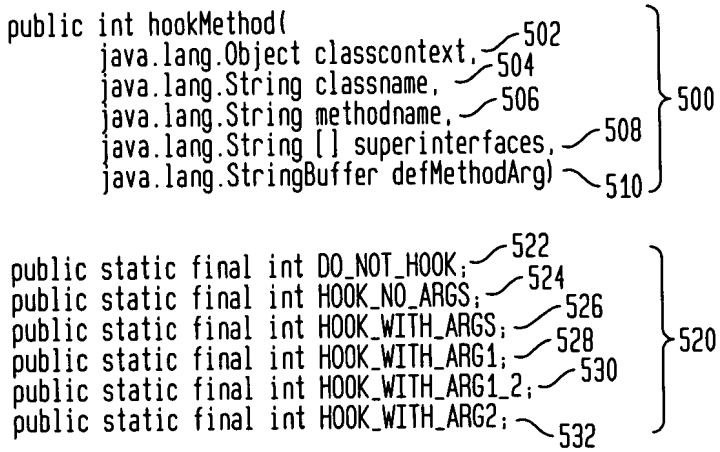

public int hookMethod(
java.lang.Object classcontext,
java.lang.String classname,
java.lang.String methodname,
java.lang.String [] superinterfaces,
java.lang.StringBuffer defMethodArg)
502
504
506
508
510
500
public static final int DO_NOT_HOOK;
public static final int HOOK_NO_ARGS;
public static final int HOOK_WITH_ARGS;
public static final int HOOK_WITH_ARG1;
public static final int HOOK_WITH_ARG1_2;
public static final int HOOK_WITH_ARG2;
522
524
526
528
530
532
520

FIG. 6A

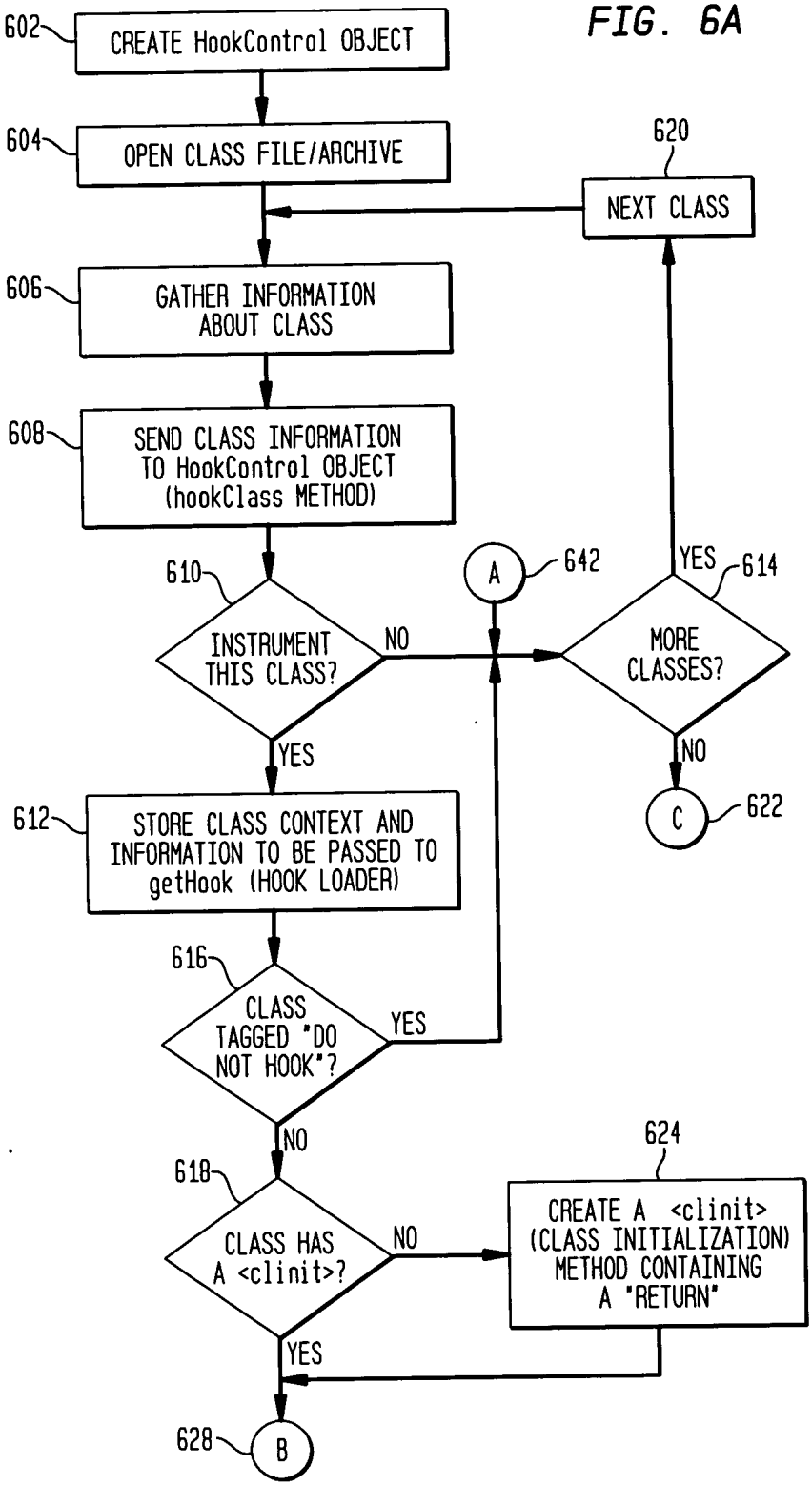

602
CREATE HookControl OBJECT
604
OPEN CLASS FILE/ARCHIVE
620
NEXT CLASS
606
GATHER INFORMATION ABOUT CLASS
608
SEND CLASS INFORMATION TO HookControl OBJECT (hookClass METHOD)
610
INSTRUMENT THIS CLASS?
NO
YES
A
642
YES
614
MORE CLASSES?
NO
C
622
612
STORE CLASS CONTEXT AND INFORMATION TO BE PASSED TO getHook (HOOK LOADER)
616
CLASS TAGGED "DO NOT HOOK"?
YES
NO
624
618
CLASS HAS A <clinit>?
NO
CREATE A <clinit> (CLASS INITIALIZATION) METHOD CONTAINING A "RETURN"
YES
628
B

FIG. 6B

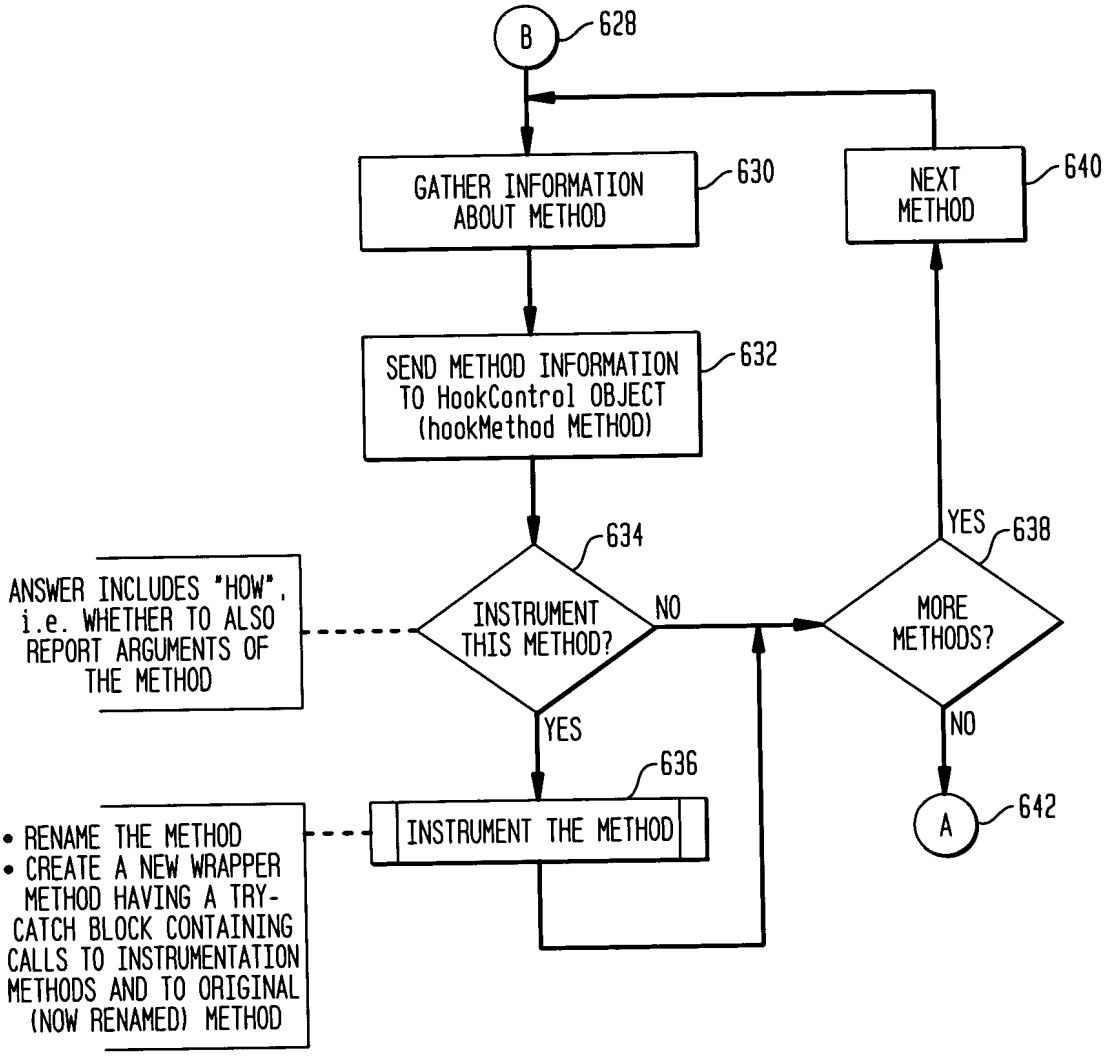

B
628
GATHER INFORMATION ABOUT METHOD
630
SEND METHOD INFORMATION TO HookControl OBJECT (hookMethod METHOD)
632
634
ANSWER INCLUDES "HOW", i.e. WHETHER TO ALSO REPORT ARGUMENTS OF THE METHOD
INSTRUMENT THIS METHOD?
NO
YES
636
• RENAME THE METHOD
• CREATE A NEW WRAPPER METHOD HAVING A TRY-CATCH BLOCK CONTAINING CALLS TO INSTRUMENTATION METHODS AND TO ORIGINAL (NOW RENAMED) METHOD
INSTRUMENT THE METHOD
NEXT METHOD
640
YES
638
MORE METHODS?
NO
A
642

FIG. 6C

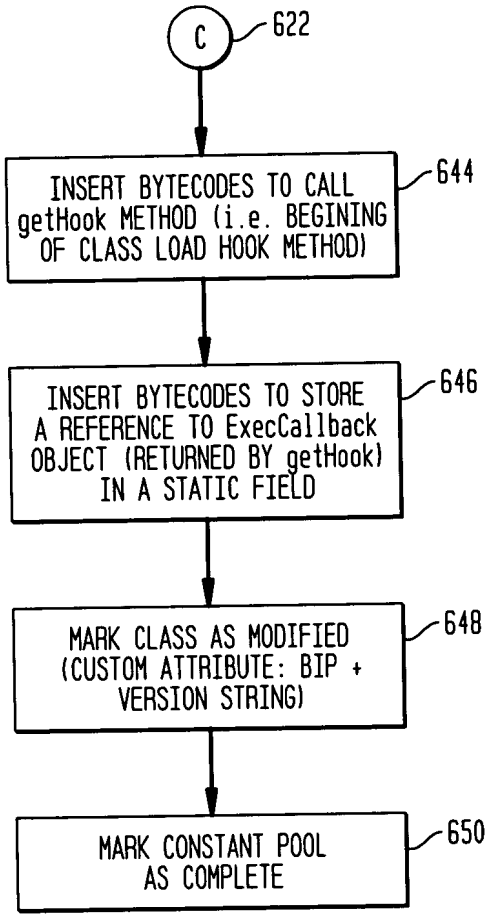

C
622
INSERT BYTECODES TO CALL getHook METHOD (i.e. BEGINING OF CLASS LOAD HOOK METHOD)
644
INSERT BYTECODES TO STORE A REFERENCE TO ExecCallback OBJECT (RETURNED BY getHook) IN A STATIC FIELD
646
MARK CLASS AS MODIFIED (CUSTOM ATTRIBUTE: BIP + VERSION STRING)
648
MARK CONSTANT POOL AS COMPLETE
650

FIG. 7

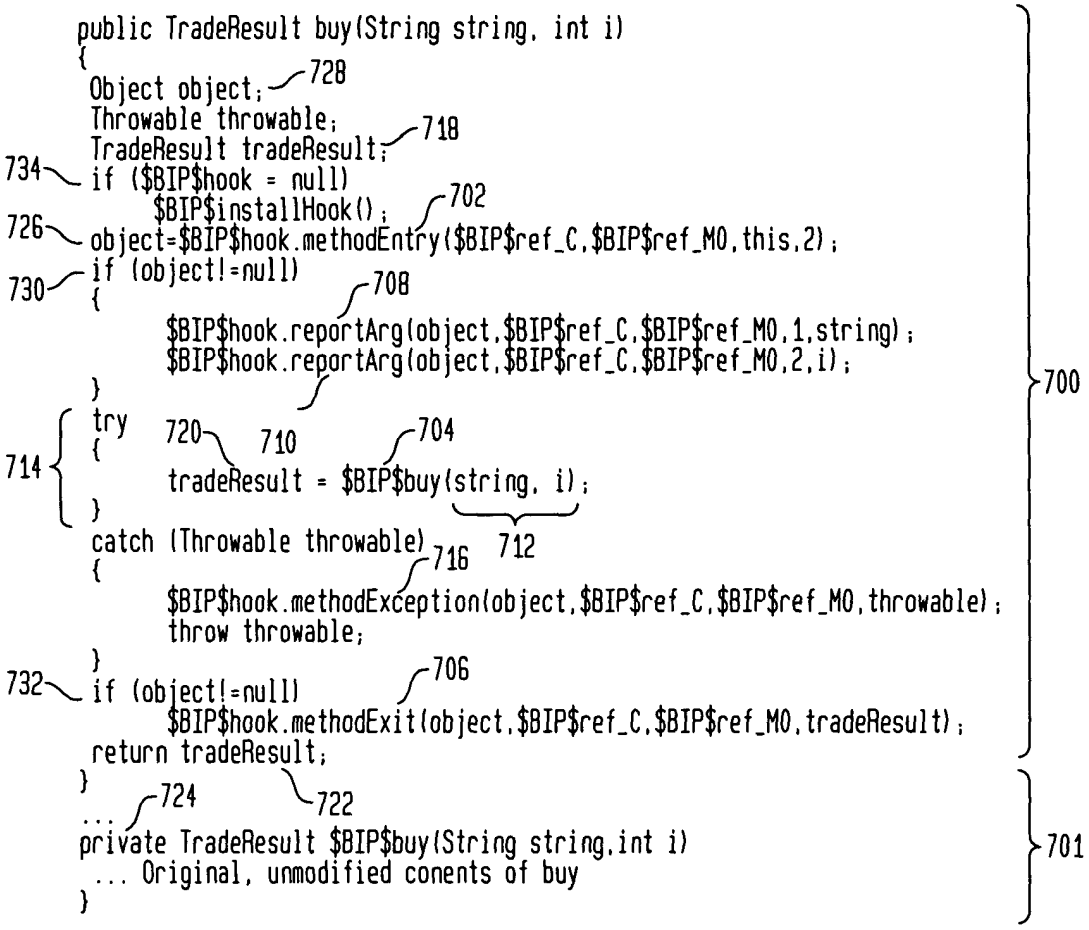

public TradeResult buy(String string, int i)
{
Object object;
728
Throwable throwable;
TradeResult tradeResult;
718
734
if (BIPhook = null)
BIPinstallHook();
702
726
object=BIPhook.methodEntry(BIPref_C,BIPref_M0,this,2);
730
if (object!=null)
{
708
BIPhook.reportArg(object,BIPref_C,BIPref_M0,1,string);
BIPhook.reportArg(object,BIPref_C,BIPref_M0,2,i);
}
try
720
710
704
714
{
tradeResult = BIPbuy(string, i);
}
712
catch (Throwable throwable)
{
716
BIPhook.methodException(object,BIPref_C,BIPref_M0,throwable);
throw throwable;
}
706
732
if (object!=null)
BIPhook.methodExit(object,BIPref_C,BIPref_M0,tradeResult);
return tradeResult;
}
724
722
...
private TradeResult BIPbuy(String string,int i)
... Original, unmodified conents of buy
}
700
701

FIG. 8A

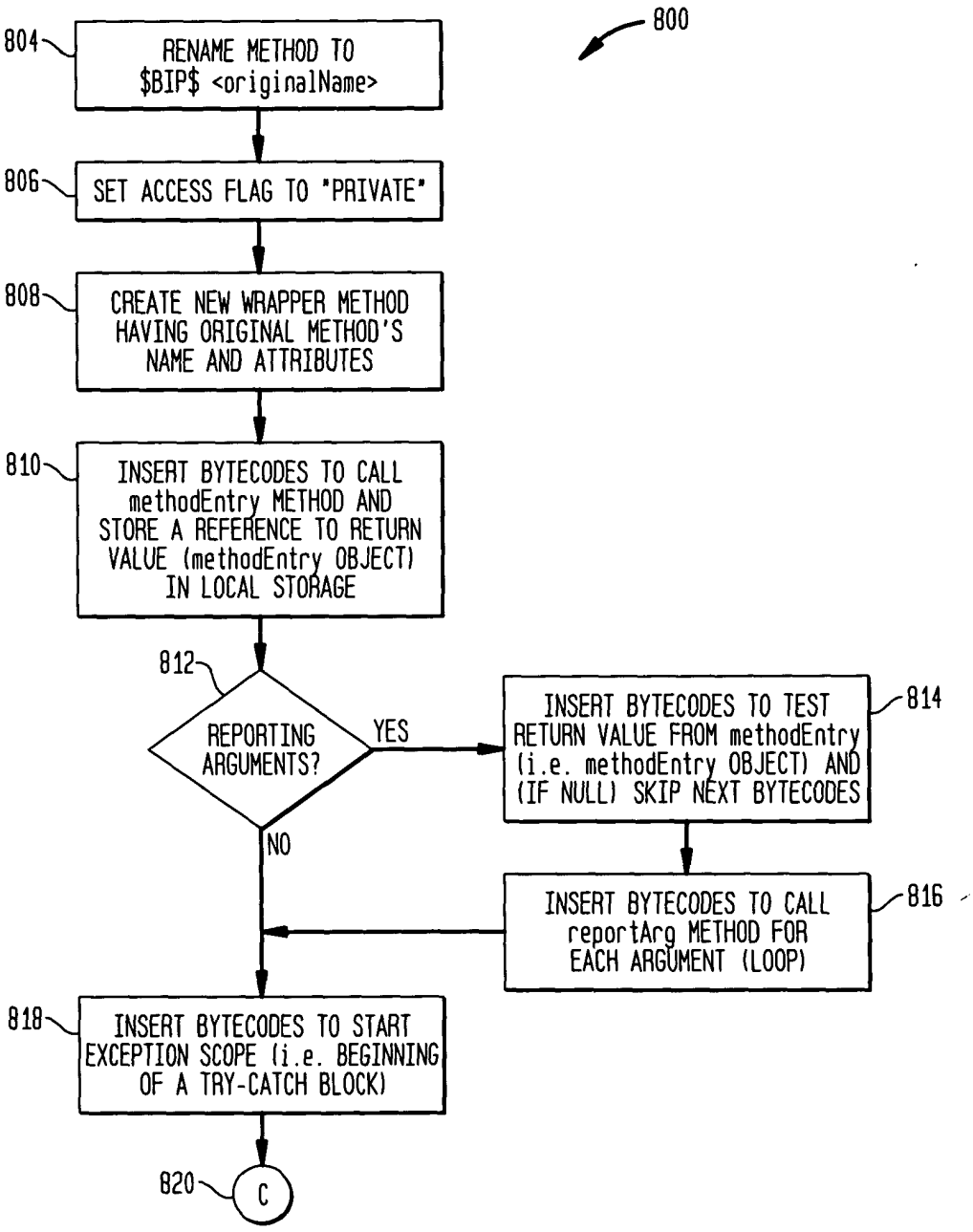

800
804
RENAME METHOD TO BIP <originalName>
806
SET ACCESS FLAG TO "PRIVATE"
808
CREATE NEW WRAPPER METHOD HAVING ORIGINAL METHOD'S NAME AND ATTRIBUTES
810
INSERT BYTECODES TO CALL methodEntry METHOD AND STORE A REFERENCE TO RETURN VALUE (methodEntry OBJECT) IN LOCAL STORAGE
812
REPORTING ARGUMENTS?
YES
814
INSERT BYTECODES TO TEST RETURN VALUE FROM methodEntry (i.e. methodEntry OBJECT) AND (IF NULL) SKIP NEXT BYTECODES
NO
816
INSERT BYTECODES TO CALL reportArg METHOD FOR EACH ARGUMENT (LOOP)
818
INSERT BYTECODES TO START EXCEPTION SCOPE (i.e. BEGINNING OF A TRY-CATCH BLOCK)
820
C

FIG. 8B

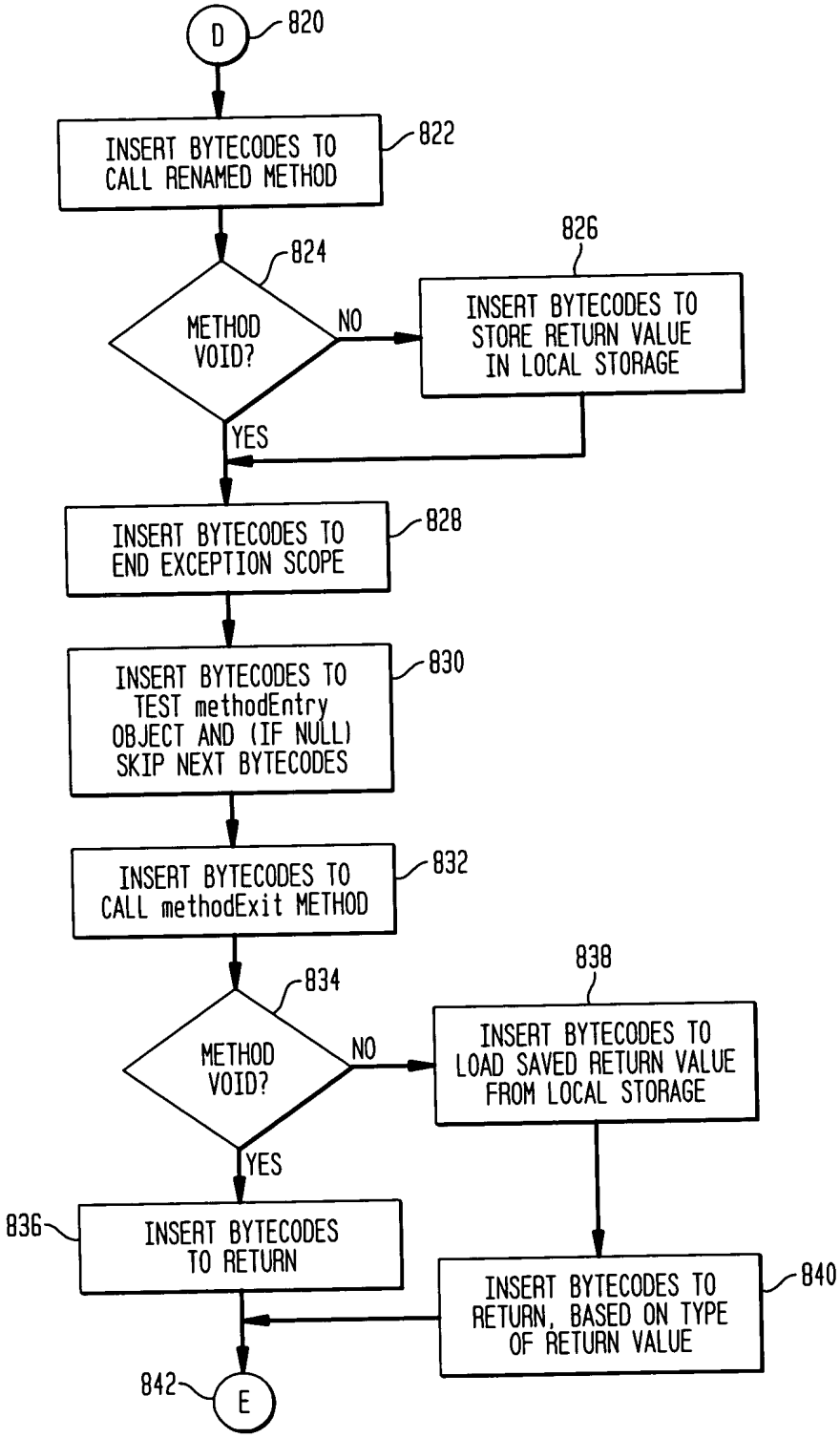

D
820
INSERT BYTECODES TO CALL RENAMED METHOD
822
METHOD VOID?
824
NO
826
INSERT BYTECODES TO STORE RETURN VALUE IN LOCAL STORAGE
YES
INSERT BYTECODES TO END EXCEPTION SCOPE
828
INSERT BYTECODES TO TEST methodEntry OBJECT AND (IF NULL) SKIP NEXT BYTECODES
830
INSERT BYTECODES TO CALL methodExit METHOD
832
METHOD VOID?
834
NO
838
INSERT BYTECODES TO LOAD SAVED RETURN VALUE FROM LOCAL STORAGE
YES
836
INSERT BYTECODES TO RETURN
INSERT BYTECODES TO RETURN, BASED ON TYPE OF RETURN VALUE
840
842
E

FIG. 8C

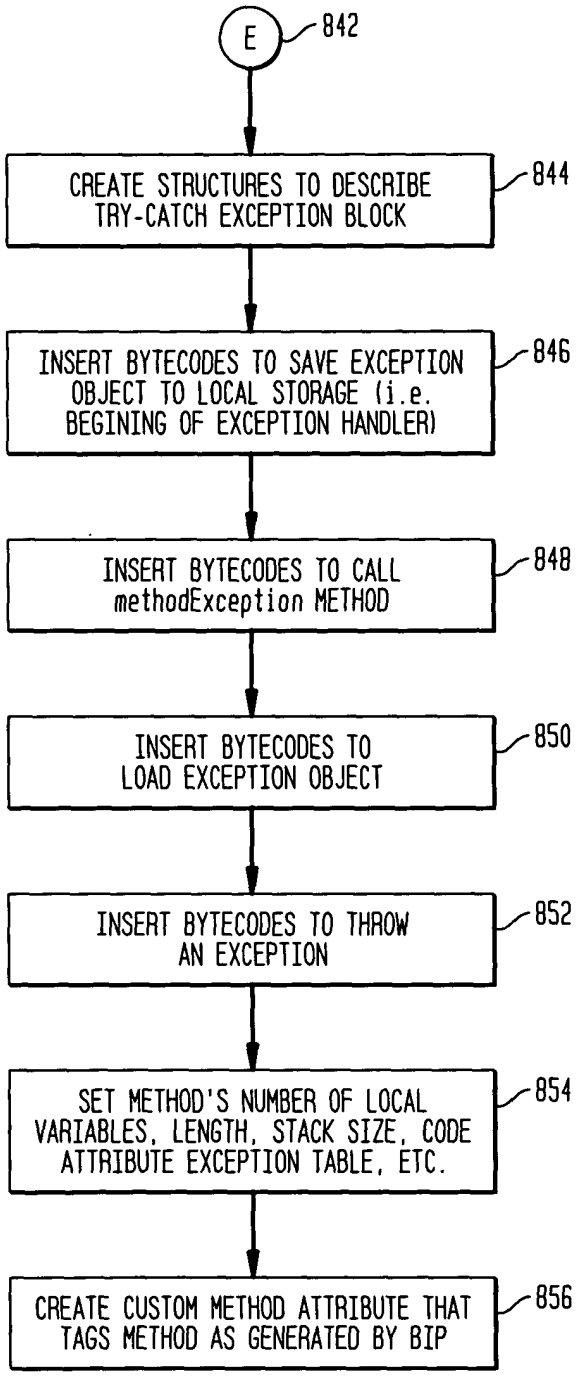

E
842
CREATE STRUCTURES TO DESCRIBE TRY-CATCH EXCEPTION BLOCK
844
INSERT BYTECODES TO SAVE EXCEPTION OBJECT TO LOCAL STORAGE (i.e. BEGINING OF EXCEPTION HANDLER)
846
INSERT BYTECODES TO CALL methodException METHOD
848
INSERT BYTECODES TO LOAD EXCEPTION OBJECT
850
INSERT BYTECODES TO THROW AN EXCEPTION
852
SET METHOD'S NUMBER OF LOCAL VARIABLES, LENGTH, STACK SIZE, CODE ATTRIBUTE EXCEPTION TABLE, ETC.
854
CREATE CUSTOM METHOD ATTRIBUTE THAT TAGS METHOD AS GENERATED BY BIP
856

FIG. 9

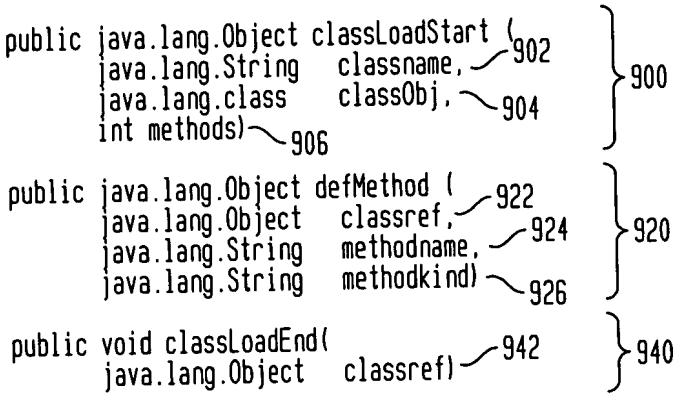

public java.lang.Object classLoadStart (
java.lang.String classname,
java.lang.class classObj,
int methods)
902
904
906
900
public java.lang.Object defMethod (
java.lang.Object classref,
java.lang.String methodname,
java.lang.String methodkind)
922
924
926
920
public void classLoadEnd(
java.lang.Object classref)
942
940

FIG. 10

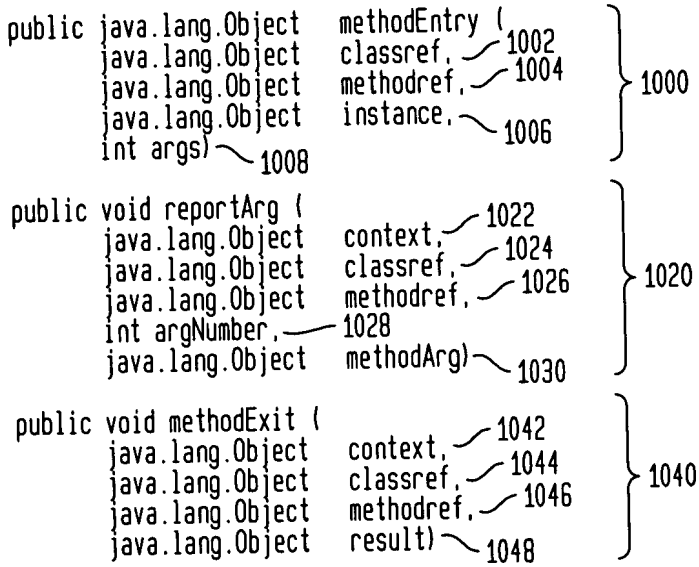

public java.lang.Object methodEntry (
java.lang.Object classref,
java.lang.Object methodref,
java.lang.Object instance,
int args)
1002
1004
1006
1008
1000
public void reportArg (
java.lang.Object context,
java.lang.Object classref,
java.lang.Object methodref,
int argNumber,
java.lang.Object methodArg)
1022
1024
1026
1028
1030
1020
public void methodExit (
java.lang.Object context,
java.lang.Object classref,
java.lang.Object methodref,
java.lang.Object result)
1042
1044
1046
1048
1040

FIG. 11

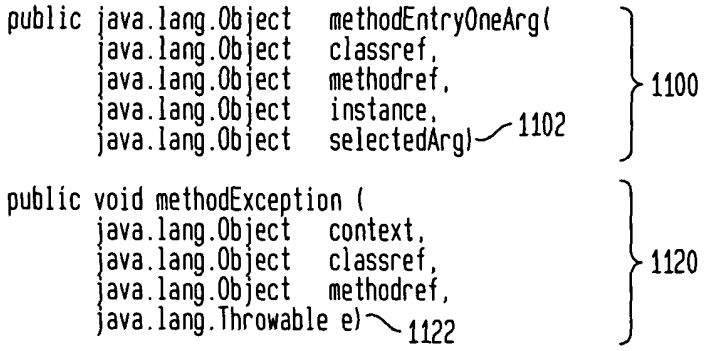

public java.lang.Object methodEntryOneArg(
java.lang.Object classref,
java.lang.Object methodref,
java.lang.Object instance,
java.lang.Object selectedArg)
1102
1100
public void methodException (
java.lang.Object context,
java.lang.Object classref,
java.lang.Object methodref,
java.lang.Throwable e)
1122
1120

FIG. 12

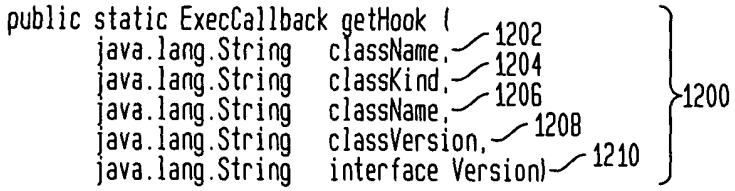

public static ExecCallback getHook (
java.lang.String className,
1202
java.lang.String classKind,
1204
java.lang.String className,
1206
java.lang.String classVersion,
1208
java.lang.String interface Version)
1210
1200

FIG. 13A

1300

```
// $Source: /data1/nebula/ccm/jade/ccm/import/arra_jlink/i2/bip/hook/RCS/NullExec?Callback.java,v $
// $Revision: 1.8 $ $Date: 2001/08/28 14:56:29 $ $Author: arav $
package i2.bip.hook;
/** An implementation of the ExecCallback that does nothing.
 * A suitable base class for a custom hook class.
 */
public class NullExecCallback
     // Explicit DoNotHook for BIC testing
     implements ExecCallback, DoNotHook {

     // Called at start of class initialization
     // Returns opaque class ref
     public Object classLoadStart(String classname, Class classObj, int methods)
     {
       return null;
     }

     // Called once for each instrumented method in the class.
     // Returns opaque method ref
     public Object defMethod(
       Object classref,
       String methodname,
       String methodkind)
     {
       return null;
     }

     // End of class initialization instrumentation
     public void classLoadEnd(Object classref) { }

     // Called at instrumented method entry.
     public Object methodEntry(
       Object classref,
       Object methodref,
       Object instance,
       int args)
     {
       return null;    // Disables methodExit & reportArg instrumentation
     }

     // Called at instrumented method entry when single arg requested.
```

FIG. 13B

1300

```
public Object methodEntryOneArg(
  Object classref,
  Object methodref,
  Object instance,
  Object selectedArg)
{
  return null;    // Disables methodExit & reportArg instrumentation
}

public Object methodEntryOneTwoArg(
  Object classref,
  Object methodref,
  Object instance,
  Object arg1,
  Object arg2)
{
  return null;    // Disables methodExit & reportArg instrumentation
}

// Called at normal instrumented method exit,
// unless returned methodEntry context is null.
public void methodExit(
  Object context,
  Object classref,
  Object methodref,
  Object result) { }

// Overloaded versions of methodExit for primitive return types.
public void methodExit(
  Object context,
  Object classref,
  Object methodref,
  int result) { }        // Covers boolean, byte, char, short, and int
public void methodExit(
  Object context,
  Object classref,
  Object methodref,
  float result) { }
public void methodExit(
  Object context,
  Object classref,
  Object methodref,
```

FIG. 13C

1300

```
  long result) { }
public void methodExit(
  Object context,
  Object classref,
  Object methodref,
  double result) { }
public void methodExit(
  Object context,
  Object classref,
  Object methodref) { }

// Called unconditionally at method exception
public void methodException(
  Object context,
  Object classref,
  Object methodref,
  Throwable e) { }

//------------------
// Argument reporting
//------------------

// Called after instrumented method entry, once per arg, if
// argument reporting was instrumented.
public void reportArg(
  Object context,
  Object classref,
  Object methodref,
  int argNumber,          // starts at 1
  Object methodArg)       // The actual argument (reference types)
{
}

// Overloaded versions of reportArg for primitive types.
public void reportArg(
  Object context,
  Object classref,
  Object methodref,
  int argNumber,          // starts at 1
  int methodArg)  // Covers boolean, byte, char, short, and int
{
}
```

FIG. 13D

1300

```
    public void reportArg(
      Object context,
      Object classref,
      Object methodref,
      int argNumber,          // starts at 1
      float methodArg)
    {
    }
    public void reportArg(
      Object context,
      Object classref,
      Object methodref,
      int argNumber,          // starts at 1
      long methodArg)
    {
    }
    public void reportArg(
      Object context,
      Object classref,
      Object methodref,
      int argNumber,          // starts at 1
      double methodArg)
    {
    }

}   // class NullExecCallback
```

FIG. 14

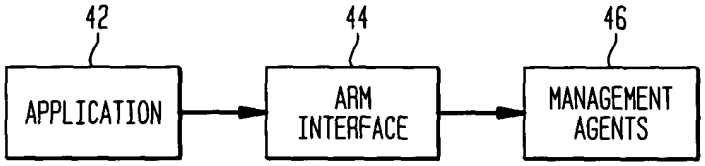


FIG. 15

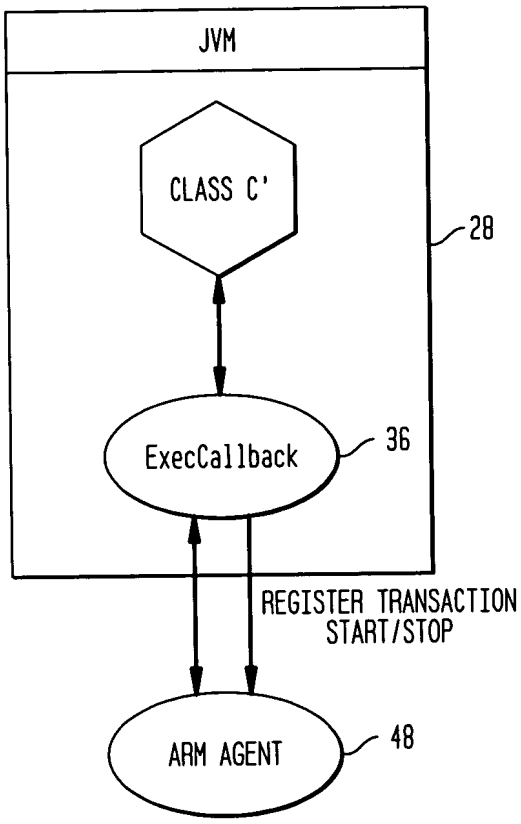

JVM
CLASS C'
28
ExecCallback
36
REGISTER TRANSACTION
START/STOP
ARM AGENT
48

FIG. 16

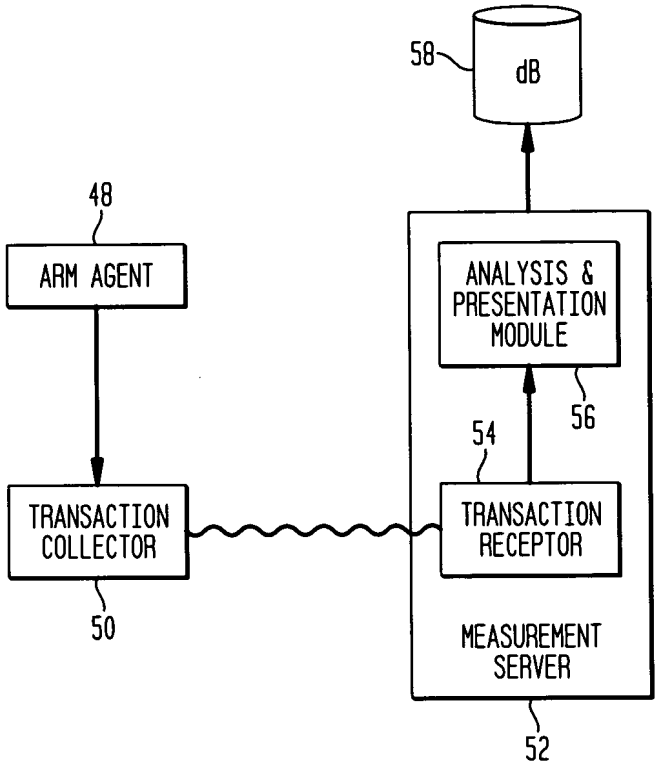

58
dB
48
ARM AGENT
ANALYSIS &
PRESENTATION
MODULE
56
54
TRANSACTION
COLLECTOR
TRANSACTION
RECEPTOR
50
MEASUREMENT
SERVER
52

FIG. 17

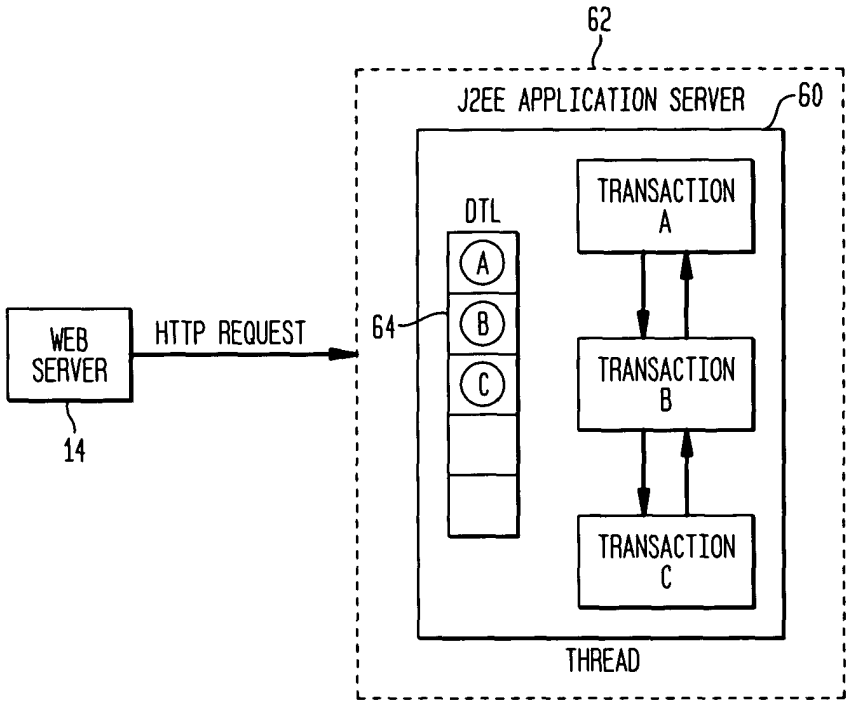

62
J2EE APPLICATION SERVER
60
DTL
A
B
C
64
TRANSACTION A
TRANSACTION B
TRANSACTION C
WEB SERVER
HTTP REQUEST
14
THREAD

FIG. 18

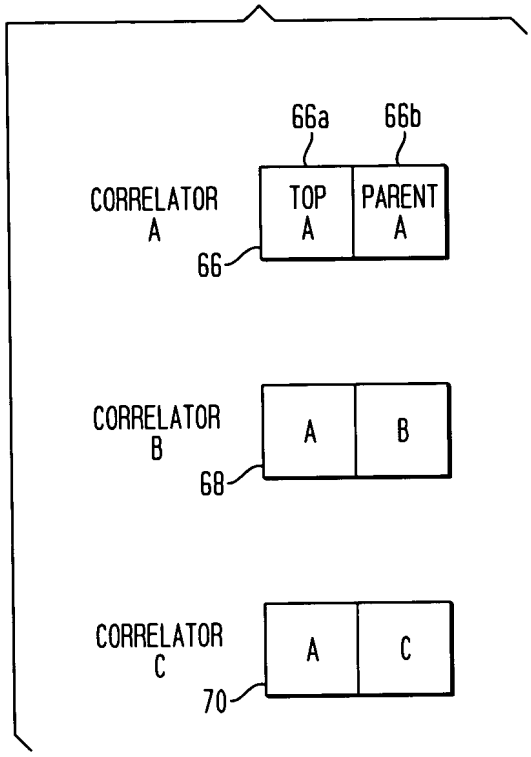

66a
66b
CORRELATOR A
TOP A
PARENT A
66
CORRELATOR B
A
B
68
CORRELATOR C
A
C
70

FIG. 19

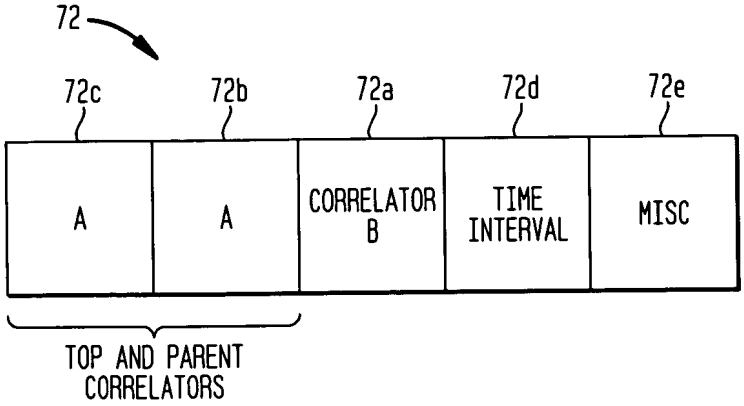

72
72c
72b
72a
72d
72e
A
A
CORRELATOR B
TIME INTERVAL
MISC
TOP AND PARENT CORRELATORS

FIG. 20

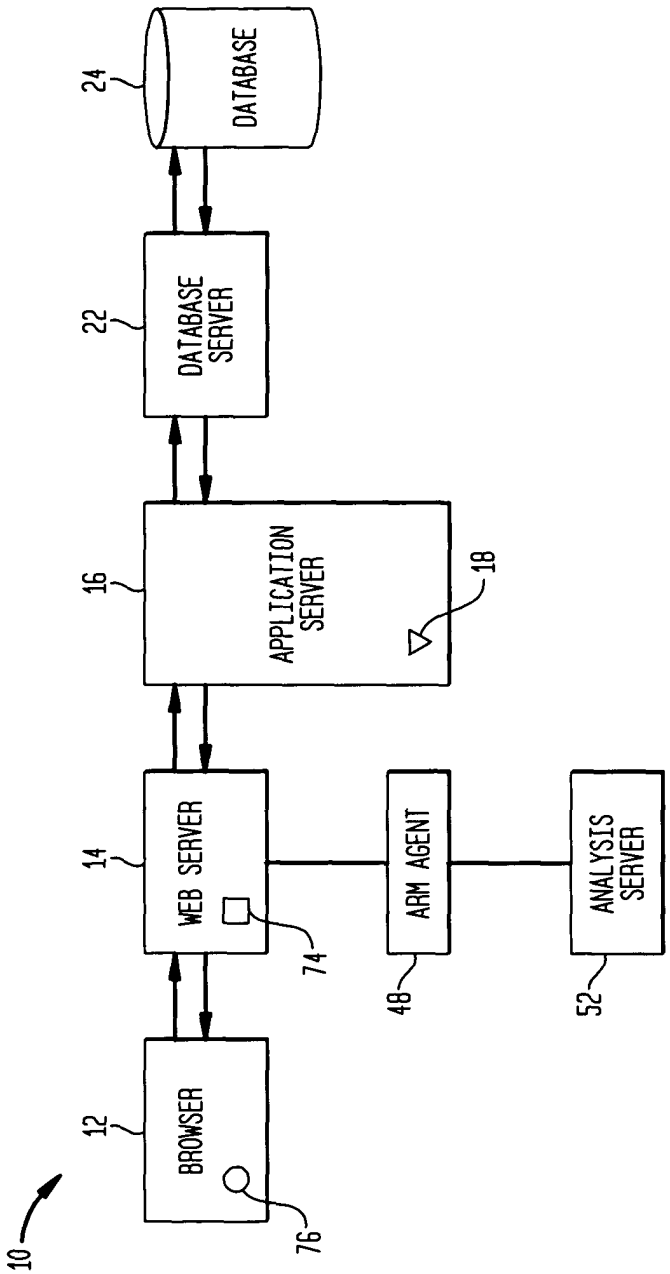

10
12
BROWSER
76
14
WEB SERVER
74
16
APPLICATION SERVER
18
22
DATABASE SERVER
24
DATABASE
48
ARM AGENT
52
ANALYSIS SERVER

FIG. 21

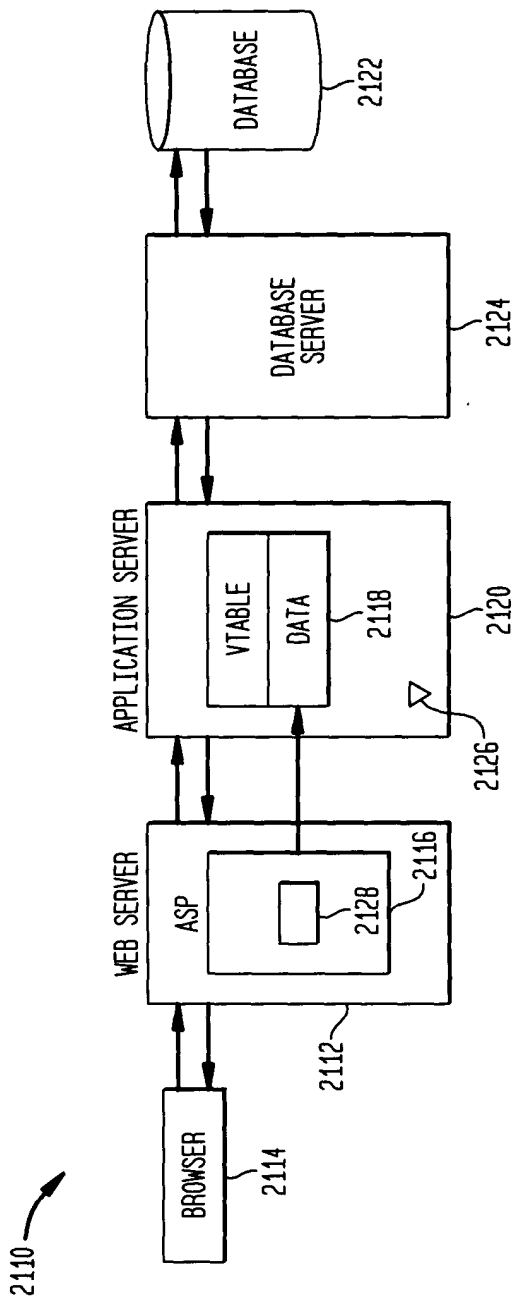

DATABASE
2122
DATABASE SERVER
2124
APPLICATION SERVER
VTABLE
DATA
2118
2120
2126
WEB SERVER
ASP
2128
2116
2112
BROWSER
2114
2110

FIG. 22

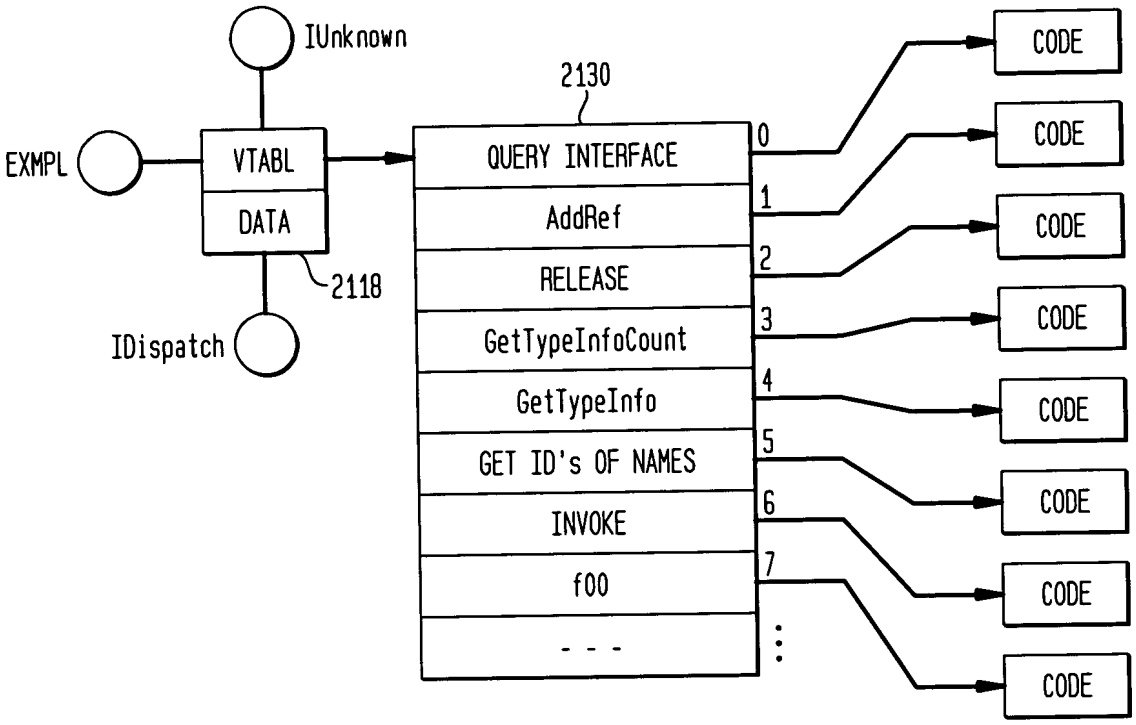

IUnknown
EXMPL
VTABL
DATA
2118
IDispatch
2130
QUERY INTERFACE
AddRef
RELEASE
GetTypeInfoCount
GetTypeInfo
GET ID's OF NAMES
INVOKE
f00
- - -
0
1
2
3
4
5
6
7
CODE
CODE
CODE
CODE
CODE
CODE
CODE
CODE

FIG. 23

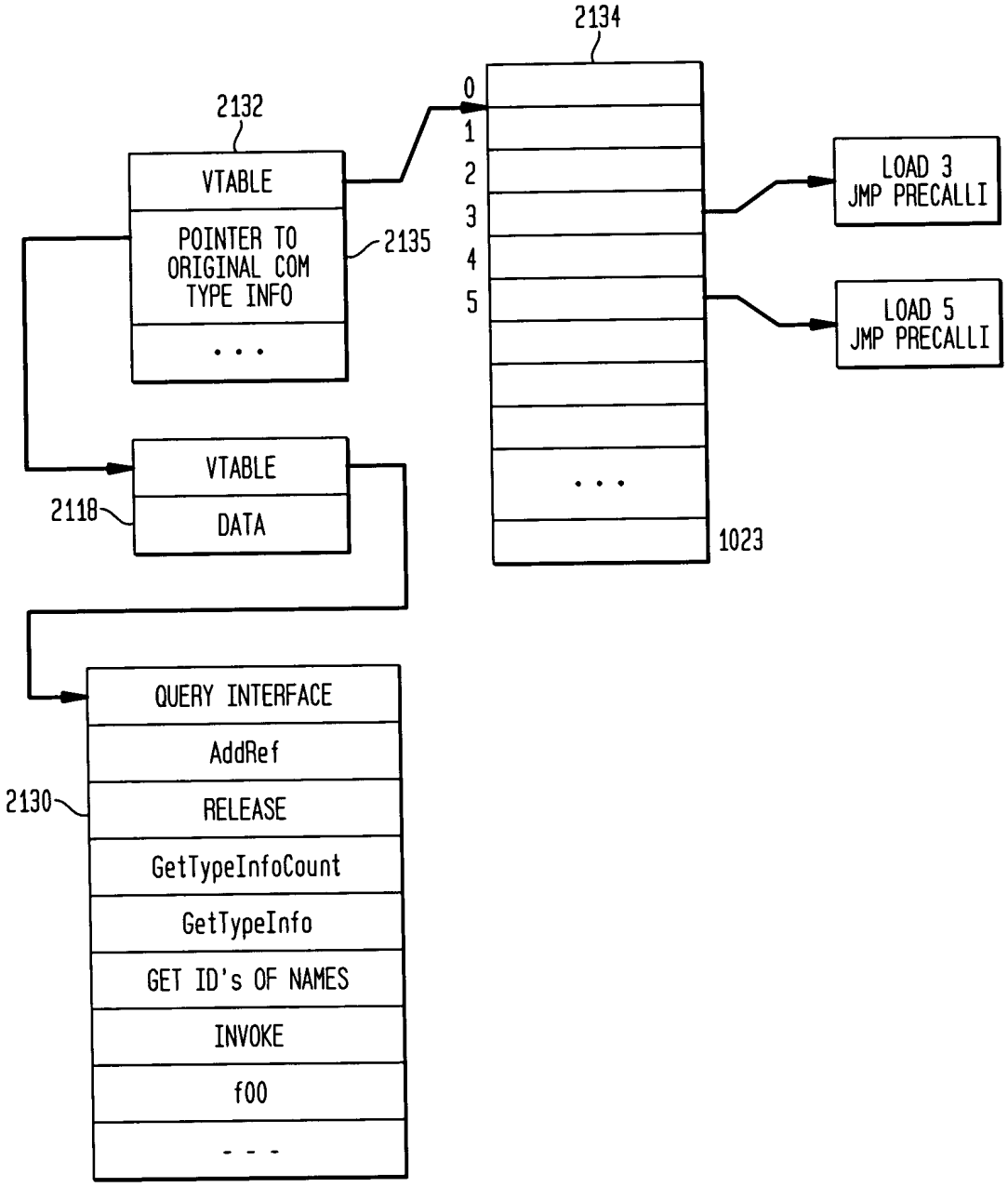

2134
0
1
2
3
4
5
1023
2132
VTABLE
POINTER TO ORIGINAL COM TYPE INFO
2135
. . .
LOAD 3 JMP PRECALLI
LOAD 5 JMP PRECALLI
VTABLE
DATA
2118
QUERY INTERFACE
AddRef
RELEASE
GetTypeInfoCount
GetTypeInfo
GET ID's OF NAMES
INVOKE
f00
- - -
2130

FIG. 24

```
PrecallInterceptor UNIVERSAL COM METHOD (METHOD #){
        DETERMINE ARGUMENTS NEEDED FOR METHOD #
        ARM START
        CALL ORIGINAL METHOD #
        ARM STOP
        }
```

FIG. 25

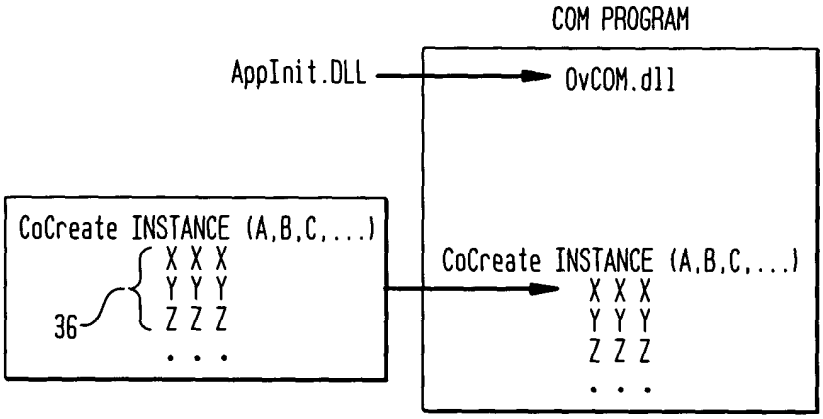


FIG. 26

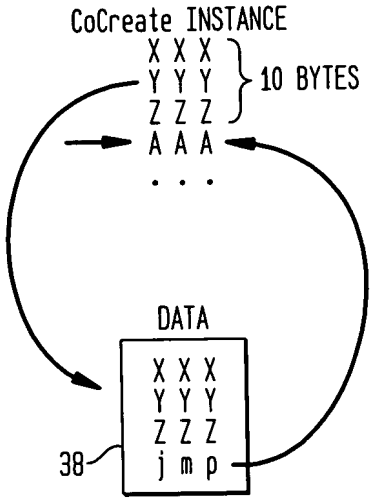


FIG. 27

```
OVTA CoCreateInstance (A,B,C) {
        .
        .
        .
   CALL CoCreateInstance (A,B,C) {
        .
        .
        .
      ACCESS B
      WRAP OBJECT REFERRED BY B
      SET B TO POINT TO WRAPPER OBJECT
      RETURN TO ORIGINAL CALLER
      }
```

FIG. 28

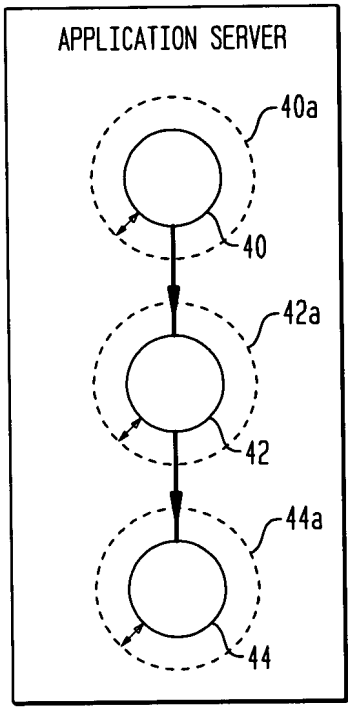
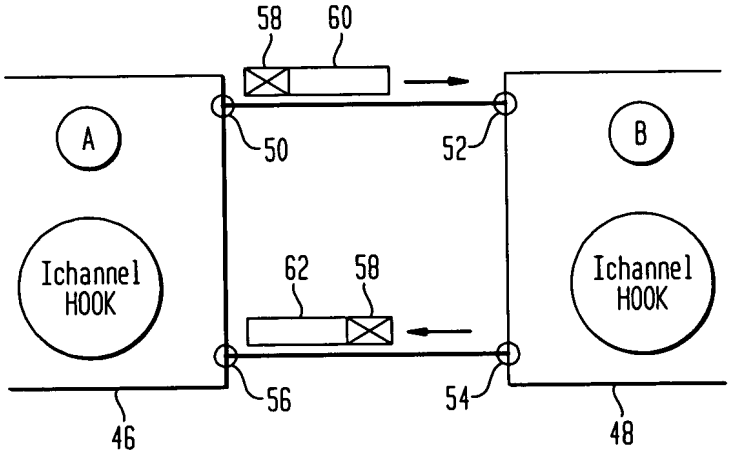

APPLICATION SERVER
40a
40
42a
42
44a
44

FIG. 29


58
60
A
50
52
B
Ichannel HOOK
62
58
Ichannel HOOK
56
54
46
48